Comments on Honeywell's Mercury Loading Estimates Associated with the Willis Avenue Site

General Comment on Loading Calculations Given the potential range (spatially, as well as temporally) of the values of the various parameters (e.g., hydraulic conductivity, hydraulic gradient, mercury concentration) used in loading calculations, the revised calculations should employ reasonable ranges of parameter values and hence generate a range of loading estimates. The range of estimates needs to reflect statistical uncertainty (e.g., uncertainty resulting from the range of estimates for an important parameter) as well as the range resulting from different sets of assumptions about a process or condition. These ranges should be separately identified.

Note also that the results of the loading calculations need to be consistent with other observations about the system (i.e., the mercury loading for the total shallow groundwater system must exceed the I-690 loadings, but be smaller than the mercury budget for the lake.)

Hydraulic Conductivity Values

Source of Hydraulic Conductivity Values The calculations relied upon hydraulic conductivity values that resulted from slug tests which were performed at a limited number of monitoring wells at the site. While slug test data are sometimes used for estimating groundwater flow rates and contaminant loadings, their usefulness is limited since the tests only provide information regarding the properties of the formation in the immediate vicinity of the well. On the other hand, aquifer pumping tests generally provide information regarding the properties of the formation over a much larger portion of the site. They therefore can provide more realistic input parameter values for estimating groundwater flow rates and contaminant loadings.

A number of aquifer pumping tests were performed in the Lakeshore Area in 1984 by Groundwater Technology, Inc. The resulting data, for the shallow and deep portions of the groundwater system, should be considered for use in the revised calculations. This is supported by the significant variations noted in the slug test data (within a given geologic unit) for the site. It is also supported by the fact that slug tests could not be performed at some locations where the wells were installed in sand and the wells responded too quickly to perform a slug test.

Use of Geometric Mean Values Geometric mean values for hydraulic conductivity values (which resulted from slug tests) were used in the loading calculations. If slug test data are included in the calculations, the arithmetic mean should be used. The fact that the geometric mean was used by Honeywell suggests that the data may be log-normal. This should be tested using the W statistic (as long as the data base is of sufficient size). To the extent that the data appear log-normal, the mean value should be estimated using a minimum variance unbiased estimator (MVUE) of the mean such as that given by Gilbert (1987). This applies to any parameter that appears log-normal, not just the hydraulic conductivity. To aid in generating a

range of possible loadings, maximum (or 95% UCL) hydraulic conductivity values should also be used. Additionally, the upper (95%) confidence limit on the MVUE could be used as an upper bound. The formula to calculate this is also given in Gilbert (1987). All three estimates of the upper bound should be listed although only the lowest value needs to be used for estimating the upper bound on the loading calculation.

Mercury Concentrations

Interstate 690 (I-690) Discharges Mercury loadings associated with the storm sewer systems, which discharge to Outfalls 040 and 041, need to be included in the loading estimates. For example, the mercury concentrations reported for outfall samples collected during baseflow conditions (prior to the performance of the IRM since the lake balance is based on 1992 data) need to be considered as representative of mercury levels present within the portions of the groundwater system that are drained by the system. The report therefore needs to include an evaluation of the outfall data and monitoring well data in consideration of flow conditions and other factors in order to assess the level of mercury in groundwater, and the resulting mercury loadings.

Use of Geometric Mean Values Geometric mean values for mercury concentrations were used in the loading calculations. However, the arithmetic mean is the appropriate measure for this purpose since the calculations represent monthly or annual loads. In general, contaminant data tend to be log-normal but the arithmetic mean must still be calculated from the log-normal data in order to integrate loads. As described above, this should be accomplished by estimating the arithmetic mean of the population by using a MVUE which is calculated using the geometric mean (Gilbert, 1987). To generate a range of possible loadings, maximum (or 95% UCL) concentrations should also be used. The 95% UCL on the MVUE can also be used as an upper bound. This is also estimated from the log-transformed data as described in Gilbert (1987). The maximum value, the 95% UCL and the 95% UCL on the MVUE should all be listed as possible estimates of the upper end of range of values. However, only the lowest value needs to be used for estimating the upper bound on the loading calculation.

Note: While the above refers to mercury loading estimates, the above comments also apply to estimates for all site-related contaminants. Likewise, while the above focuses on groundwater loading estimates, similar rationale need to be employed for all other potential contaminant migration pathways. Further, the geometric mean is only useful as a statistical tool to compare different data sets when the underlying distribution is log-normal. The geometric mean should not be used in any mass transport or other engineering calculations anywhere in the report. If the underlying distribution of a given variable is log-normal then MVUE statistics should be used to estimate both the arithmetic mean and the UCL on the arithmetic mean for use in subsequent calculations. The only limitation on the application of the MVUE occurs when the data set is too small to clearly identify its underlying nature (normal vs log-normal). In this case, the arithmetic mean and the maximum values should be used in the loading calculations.